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Frequency of External Defect and Skidding Damage in Lodgepole Pine Stands in Colorado and Wyoming

J.M. Schmid and S.A. Mata[1]

The frequency of 8 defect characteristics and 3 classes of skidding damage was assessed in lodgepole pine stands in northern Colorado and southern Wyoming. In general, the most common natural defect in all stands was a forked top, although scars, crooks, or spikes were equally or more common in two stands. Skidding damage was present on more than 50% of the trees in some plots reflecting carelessness by skidder operators and ineffective timber sale administration. Damage was greater in stands skidded with mechanical skidders.

Keywords: Defect, harvesting damage, partial cutting, *Pinus contorta*

Defects generally reduce the volume of sound lumber or lower the structural properties of lumber derived from forest trees. They may render a tree useless for lumber depending on where they occur in the bole. A serious defect at either end of the bole may not significantly reduce the volume derived, while a defect in the center of the log may cull the entire log. Some defects may eventually cause a tree to become the focus tree for attacks by the mountain pine beetle (MPB) (*Dendroctonus ponderosae* Hopkins) and thus create new MPB infestations (Eckberg et al. 1993). Defects in lodgepole pine (*Pinus contorta* Douglas) result from several factors, including biotic agents, physical factors, growing conditions, genetic stock, and injury from mechanized equipment during logging.

Biotic agents frequently cause natural defects such as crooks, spikes, or dead tops. Some insects, particularly tip moths (*Rhyacionia* spp.), scolytid and curculioid beetles kill the leaders of young trees. The lodgepole terminal weevil (*Pissodes terminalis* Hopping) kills the leader of young trees but not the laterals (Stark and Wood 1964). After the leader is killed, a lateral branch usually becomes the leader, but a crook develops in the bole as the tree matures. The crook weakens the bole such that the top log is normally culled when the tree reaches maturity (F. Fowler 1992, personal communication).[2] Porcupines may also cause a crook by girdling the bole several feet below the leader. The girdling results in either a dead top or multiple leaders, which negate future height growth (F. Fowler 1992, personal communication). In contrast to the insect-caused crook, a porcupine-caused crook also has a spike (the dead stem above the girdle) subtending from the point where the crook was created.

Defects such as scars, broken tops, and leaning trees can be caused by trees falling during windstorms, but storm-caused defects are not well documented in the literature. Leaning trees may be caused by wind, especially in thinned stands in May and June when soils are moist and trees may be partially uprooted (J.M. Schmid, unpublished observation). Forked-top trees may be a genetic defect but this has not been proven. The severity of defect in forked-top trees depends on the location of the fork in the bole. Forked-top trees are also prone to damage by wind that may break off one of the forks (J.M. Schmid, unpublished observation).

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[1] *J.M. Schmid, Entomologist; S.A. Mata, Biological Technician, Rocky Mountain Forest and Range Experiment Station. Headquarters is in Fort Collins, in cooperation with Colorado State University.*

[2] *Information gained through personal communication with F. Fowler, Forester, Black Hills National Forest, South Dakota, 1992.*

Mechanical injury is a place on the bole where the bark has been removed and the wood exposed by mechanized equipment. This injury is important because it can reduce growth and permit pathogens to enter the tree. The injury is not important in unmanaged stands until the first thinning or harvesting operation which may be at least 60 years after seedling establishment. However, in managed stands regenerated from harvesting cuts, mechanical injury can result in the early years of the stand when the overstory is being removed after seedling establishment. Thus, mechanical injury may be more detrimental when created early in the life of a stand rather than later.

This note presents information on various natural defects and human-caused mechanical injury in stands of lodgepole pine (*Pinus contorta* Douglas) in northern Colorado and southern Wyoming. The frequencies of natural defects prior to partial cutting and the frequency of skidding damage incurred during the partial cutting are presented.

Methods

The data presented in the results and discussion section were byproducts of a research study investigating the relationship between different growing stock levels (GSL)[3] of lodgepole pine and subsequent tree mortality caused by the MPB. For that study, a series of 2.5-acre plots were installed in unmanaged lodgepole pine stands in northern Colorado and southern Wyoming. Four 2.5-acre plots were installed at 11 locations and 5 plots were installed at one location. The stands were essentially pure pine with an occasional aspen (*Populus tremuloides* Michx.) or Engelmann spruce (*Picea engelmannii* Parry) in some plots. Average stand diameter exceeded 6 in dbh, and basal area ranged from 120 to 180 ft^2/acre for all Colorado locations. Average stand diameter exceeded 7.5 in dbh and basal area generally exceeded 200 ft^2/acre in all Wyoming locations.

We inventoried all trees in the central 1.25 acres of each 2.5-acre plot before harvest. We measured the diameter at breast height of each tree and recorded the following defects when present:

Forked top—A tree having a main bole that subdivided at some point above the base and, thereafter, supported two or more live crowns.

Multiple forked top—A forked-top tree in which one of the forks subdivided and supported two or more live crowns.

Dead top—A tree with a live crown but a dead leader.

Sweep—A gradual curvature of the main bole.

Leaner—A tree with a bole not growing vertically.

Scar—A place on the bole where the bark has been removed and the wood is exposed by a non-human factor such as fire or a falling tree.

Crook—An abrupt bend in the bole.

Spike—A dead stem, usually the former live crown that has died, subtending from a crook in the bole.

The frequency of each defect for each location is based on the combined inventories of the plots at each location. The surveyed area thus equaled 5 acres for 11 locations and 6.25 acres for 1 location (Brush Creek).

After stand inventory, all the stands except the controls were marked to specific GSLs. Leave trees were selected on the basis of diameter, apparent health, crown development, and spacing. We emphasized leaving the best trees equally spaced. After the stands were cut to the designated GSL, we surveyed the felling and skidding damage because we thought that such damage might predispose the trees to MPB attack. Each tree was inspected for skidding damage and classified into one of three classes based on the amount of bole area affected: I-less than 1 ft^2 of bark removed or phloem exposed, II-1 to 3 ft^2 of bark removed or phloem exposed, and III-more than 3 ft^2 of bark removed or phloem exposed (fig. 1).

Because plots were cut to different GSLs at different locations, each location will have data only for the GSLs present at that location. No skidding damage data are presented for Doe Creek, Hinman Park, Colorado State Forest, Mill Creek, and Horse Creek locations because plots at these locations were uncut when this note was prepared. The Illinois River and KOA locations were logged by pole cutters who usually cut the trees into 8-ft and 16-ft lengths and rarely used skidders to move the logs. Logs in all other locations were skidded tree-length with mechanical skidders.

Results and Discussion

The most frequently occurring defect was a forked top. Average frequency was 8.9% for all locations (table 1). Other defects had equal or greater frequency as forked tops at Divide Peak and Horse Creek but these defects were much less frequent than forked tops in the other locations. The average percentage of forked-top trees in ponderosa pine (*P. ponderosa* Lawson) was 6.6% for eight locations (Schmid et al. 1989), so the incidence appears about the same in both species. However, the overall average for the ponderosa pine locations was inflated by a high percentage at one location. When that datum is removed, the average frequency of

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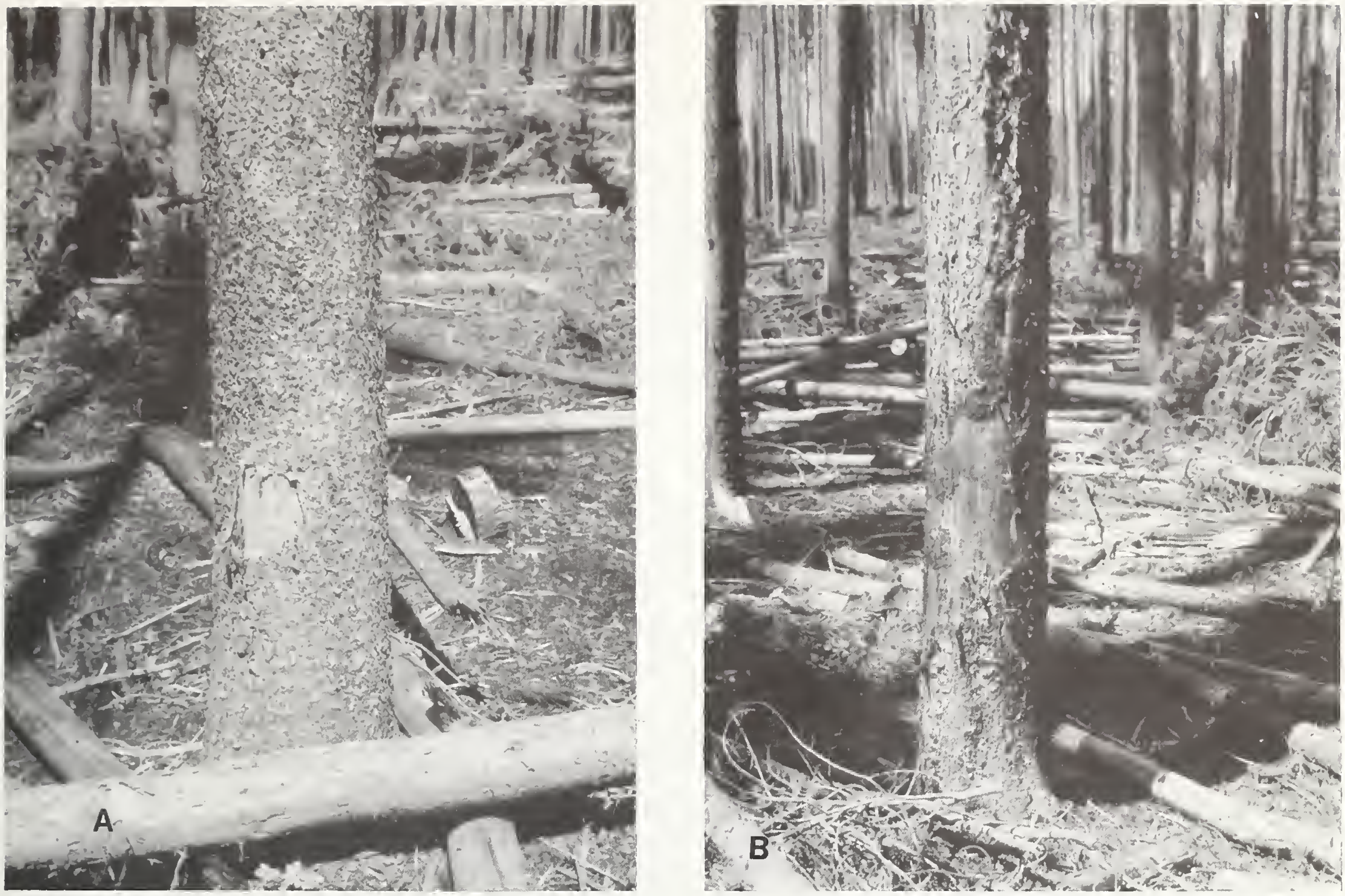
[3] *Growing stock level is defined as the amount of residual basal area when the average stand diameter > 10 in.*



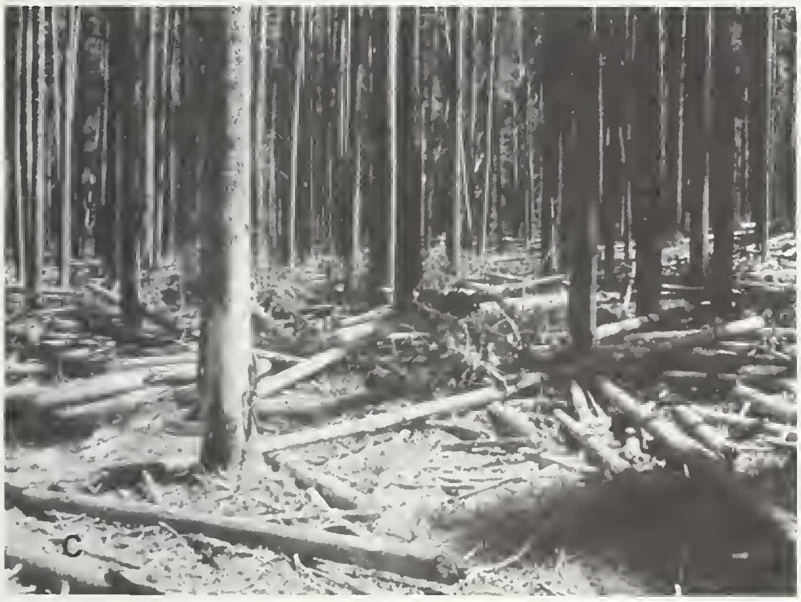


Figure 1.—Examples of skidding damage; Class I (A), Class II (B), and Class III (C).

forked tops for lodgepole pine is almost double the average for ponderosa pine. We cannot explain why the incidence is different for the two species.

As noted earlier, the decrease in value of a forked-top tree is a function of the location of the fork in the bole. Forks well into the crown cause less timber loss than forks in the lower bole. Forked-top trees may be left as leave trees in partial cuts if the tree is otherwise healthy. However, recent evidence suggests that forked-top trees may serve as focus trees for MPB attack (Eckberg et al. 1993) and thus be less desirable as leave trees.

Crooks and spikes were present on average in about 4% of the trees, although Divide Peak had a frequency of >11% for crooks and Horse Creek had a frequency of >11% for spikes. Natural scars also were present on 22% of the trees at Horse Creek. There is no apparent explanation for the higher percentages of crooks, spikes, and scars at these locations except that *Armillaria* root disease and fallen trees were present at Horse Creek. If the *Armillaria* killed the trees, their subsequent falling could contribute to the number of scarred trees and perhaps to the number of trees with spikes.

Skidding damage varied by location and damage class (table 2). Class I damage on the generally unskidded plots averaged 7.6% for Illinois River and 2.6% for KOA. All other locations except Blue Ridge averaged more than 22% Class I damage. Class I skidding damage on the Blue Ridge plots probably would have averaged >20% but the operators skidded only the periphery of the GSL 90 plot. Class II and III skidding damage was not present in the Illinois River and KOA plots but averaged 16.9% for the Divide Peak plots and 6.4% for the North

Table 1.—Frequency (%) of defect characteristics in lodgepole pine by location. Number in parentheses below each location indicates the number of trees examined at that location.

	Colorado							Wyoming				
Defect characteristic	Blue Ridge (1659)	Burgundy Flats (1435)	Doe Creek (3435)	Ill. River (2674)	Hinman Park (1444)	KOA (1960)	CO State Forest (1972)	Brush Creek (3384)	Divide Peak (2156)	North Savery (3442)	Mill Creek (3157)	Horse Creek (3142)
Forked top	9.3	7.7	5.6	7.9	13.2	5.1	7.1	11.6	11.0	8.1	10.7	10.5
Multiple fork	0.2	2.2	0.0	0.6	0.8	0.4	0.1	0.1	1.1	0.0	0.1	2.6
Dead top	5.0	2.2	0.1	1.2	1.2	1.5	1.4	1.9	3.2	3.2	2.3	3.9
Sweep	3.5	2.0	0.0	3.7	2.8	4.4	1.4	1.5	5.3	3.3	1.7	4.3
Leaner	0.9	4.4	0.3	1.3	6.0	2.2	1.3	0.9	2.8	1.5	0.6	2.8
Scar	1.0	4.1	0.0	2.7	1.4	3.5	1.4	1.5	4.6	3.8	0.2	21.6
Crook	2.0	2.9	0.2	4.4	5.0	4.5	2.8	2.8	11.5	2.8	1.4	6.1
Spike	1.8	5.2	0.1	3.4	2.8	1.8	4.6	3.3	5.4	6.3	2.5	14.8

Table 2.—Percent of leave trees with skidding damage by GSL at each location. Numbers in parentheses equal the number of leave trees per acre.

		Location[a]						
Damage class[b]	GSL	Blue Ridge	Burgundy Flats	Illinois River	KOA	Brush Creek	Divide Peak	North Savery
I	40- 60	16.5 (68)	30.7 (81)	13.8 (98)		60.0 (76) 28.4 (76)	51.4 (56)	51.7 (48)
	75- 90	28.7 (120) 6.3 (151)	22.9 (105)	4.7 (172)	4.0 (198)	53.0 (148)	38.1 (145)	27.4 (178)
	100-120		24.6(224)	4.3 (262)	3.7 (218) 0.9 (278)	37.7 (196)	33.5 (196)	29.4 (264)
II	40- 60	0.0	4.0	0.0		0.0	27.1	20.0
	75- 90	0.6	1.5	0.0	0.0	2.2	16.6	15.2
	100-120		3.2	0.0	0.0	0.9	14.3	8.2
III	40- 60	1.2	1.0	0.0		0.0	8.6	6.7
	75- 90	0.0	0.8	0.0	0.0	0.0	12.7	4.5
	100-120		0.7	0.0	0.0	0.0	3.3	2.7

[a] *Some locations had more than one plot in a GSL range and when the percent damage for each plot differed by more than one percentage point, both values are presented. If the percent damage differed by less than a percentage point, the average of the two values is presented.*

[b] *I = less than 1 ft^2; II = 1 to 3 ft^2; III = 3 ft^2 or more.*

Savery plots (table 2). The variation in skidding damage by location mainly reflects the type of equipment used. Damage was considerably higher where mechanical skidders were used and logs were skidded tree-length.

Skidding damage varied among the GSLs, but did not increase with increasing GSL. In fact, the lowest GSLs exhibited some of the highest percent damage in each class (table 2). Because lodgepole bark is relatively thin (Mason 1915) and easily scraped off during certain times of the year, a portion of this damage may be attributed to bark thickness and condition. Similarly, trees per acre in lodgepole pine stands is usually greater than trees per acre in ponderosa pine stands of comparable diameters, so some damage also may be attributed to the higher stand densities. However, although thin bark and stand density could account for part of the high percentage of skidding damage, the most obvious explanation for the damage is a combination of skidder operator's attitude and carelessness coupled with ineffective sale administration. Skidding damage of 50%, and more importantly class II damage >20% and class III damage >7% is almost impossible to create in a GSL 40 on level ground unless the operator has a total disregard for the leave trees. Skidding damage of 50% or even indeed 20% is totally unacceptable especially when contrasted with damage of <10% in ponderosa pine (see Schmid et al. 1989).

Skidding damage obviously affects future growth and physical appearance. In the study areas, class I damage usually consisted of small nicks on the bole

created by branch or bole rubs (fig. 1A). This type of damage will probably heal and not cause a growth reduction in future years. Class II and III damage, on the other hand, consisted of sizeable patches of missing bark created mostly by tire rubs (fig. 1B and 1C). These patches will probably not heal. More importantly, the loss of one-fourth to one-third of the circumferential phloem tissue will significantly reduce growth in future years.

The silvical purpose of intermediate cuttings in lodgepole pine stands is to reduce competition among trees in dense stands by removing the undesirable or poorer trees and thus increase the growth of the trees left on the site. Only healthy, well-formed trees with minimal defect are chosen to remain so that the growth potential of the trees and the stand can be reached. A basic premise in this silvicultural prescription is that the leave trees are expected to survive the intermediate cutting unscathed. Loggers and forest managers must realize that wounding these trees through skidding damage opens the opportunity for pathogens, reduces growth, decreases visual appeal, and thus negates much of the benefits of intermediate cuttings.

Conclusions

Damage frequencies observed in this study represent poor harvesting practices (fig. 2). If educating loggers to the detrimental aspects of harvesting damage fails to reduce leave tree damage, forest managers must take appropriate action by stipulating damage assessments for tree wounding, requiring the use of specific equipment, prohibiting tree-length skidding, and requiring the felling of unmerchantable trees.

In addition to the physiological problems caused by the damage, the appearance of severely damaged trees is unsightly. Partial cutting in lodgepole pine forests is more aesthetically pleasing than clearcutting because it leaves a considerable portion of the stand and the repulsive results of tree harvesting are less evident. However, if skidding damage of the magnitude shown in this survey is not drastically reduced, then partial cutting will be considered just as repulsive as clearcutting, and could be lost as a viable means for preventing losses to the MPB (see McGregor et al 1987).

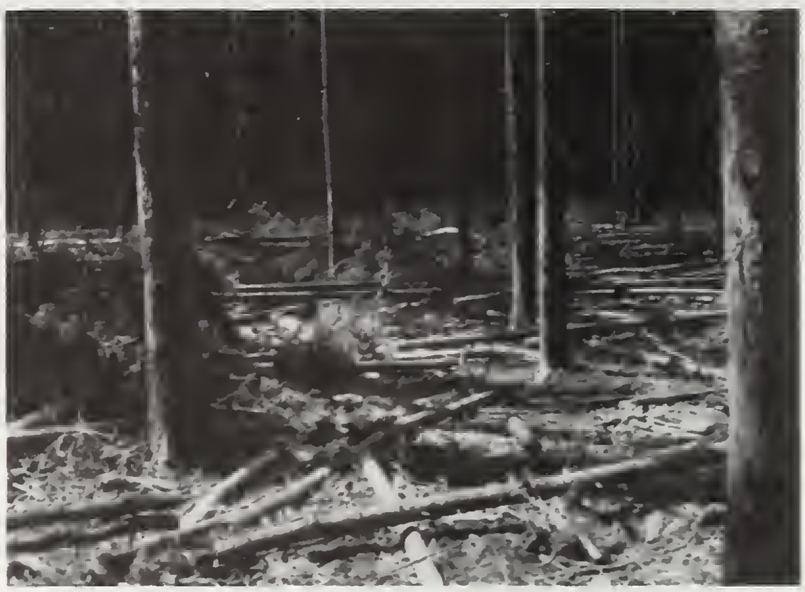


Figure 2.—Skidding damage within one of the plots.

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